Strategic Astrophysics Technology

Predictive Thermal Control Technology for potential HabEx Mission

Completed Technology Project (2017 - 2019)

Project Introduction

Imaging and characterize Earth-like planets requires the ability to block 1010 of the host star's light with a 10-11 stability. For an internal coronagraph, this requires correcting wavefront errors and keeping that correction stable to a few picometers rms for the duration of the science observation. Providing this capability requires a thermally stable telescope. Predictive Thermal Control Technology (PTCT) is a multiyear effort to develop, demonstrate, mature towards TRL6, and assess the utility of model based Predictive Thermal Control (PTC) technology to enable a thermally stable telescope. PTCT demonstrates technology maturation by model validation and characterization testing of traceable components in a relevant environment. PTCT's efforts are conducted in consultation with the Cosmic Origins Office and NASA Program Analysis Groups. To mature Thermally Stable Telescope technology, PTCT has defined three objectives: 1. Validating models that predict thermal optical performance of real mirrors and structure based on their structural designs and constituent material properties, i.e. coefficient of thermal expansion (CTE) distribution, thermal conductivity, thermal mass, etc. 2. Deriving thermal system stability specifications from wavefront stability requirement. 3. Demonstrating utility of a Predictive Control thermal system for achieving thermal stability. To achieve these objectives, PTCT defined a detailed technical plan with five quantifiable milestones: 1. Develop a high-fidelity flight traceable model of the AMTD-2 1.5 meter ULE® mirror, including 3D CTE distribution and reflective optical coating, that predicts its optical performance response to steady-state and dynamic thermal gradients under bang/bang and proportional thermal control. 2. Derive specifications for thermal control system as a function of wavefront stability. 3. Design and build a predictive Thermal Control System for a 1.5 meter ULE® mirror using new and existing Commercial-off-the-shelf components that sense temperature changes at the ~1mK level and actively controls the mirror's thermal environment at the ~20mK level. 4. Validate the model by testing a flight traceable 1.5-m class ULE® mirror in a relevant thermal vacuum environment in the MSFC X-ray and Cryogenic Facility (XRCF) test facility. 5. Use the validated model to perform trade studies to determine how thermo-optical performance can be optimized as a function of mirror design, material selection, mass, etc. PTCT advances the SOA by developing a predictive control method that uses a thermal 'model in the loop' to control the thermal system. Our goal is to demonstrate a 'system' technology solution that enables a thermally stable telescope, for exoplanet science, that keeps the telescope at a constant temperature independent of where it looks on the sky.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Strategic Astrophysics Technology

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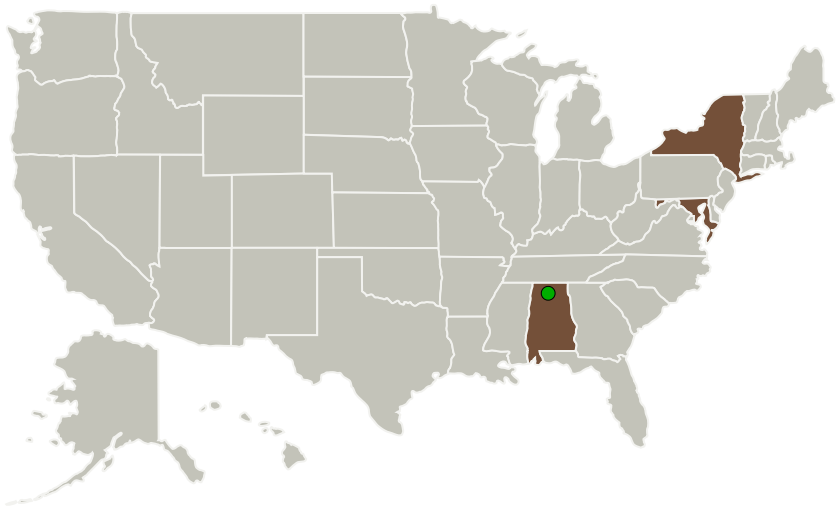
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations	
Alabama	Maryland
New York	

Project Management

Program Director:

Mario R Perez

Program Manager:

Mario R Perez

Principal Investigator:

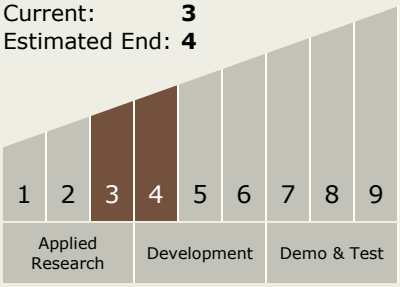
H P Stahl

Co-Investigators:

Steven J Lambing
Michael R Effinger
Gary Matthews
William R Arnold
Thomas E Brooks
Perry Voyer
Ronnie Eng
Winfield S Smith
Richard D Siler
Robert Egerman

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

Continued on following page.

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Technology Areas *(cont.)*

- TX08 Sensors and Instruments
  - TX08.2 Observatories
    - TX08.2.1 Mirror Systems

Target Destination

Outside the Solar System